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(54) **Heating system and method for heating a reactor**

Heizungsanlage und Verfahren zur Heizung für einen Reaktor

Système de chauffage et procédé pour chauffer un réacteur

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(56) References cited:
WO-A-00/39840
US-A- 5 635 409
US-A- 5 775 889

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Description

[0001] The present invention relates to a heating system and a method for heating a reactor for one of deposition and oxidation.

[0002] During the manufacture of integrated circuits such as memory products substrates, especially semiconductor wafers, are processed in high-temperature ovens, called reactors, in order to deposit layers of isolating, semiconducting or conducting material. These reactors can be suited for the processing of a plurality of wafers at one time. The wafers are placed on a wafer support inside the reactor. The deposition reactor and, thus, the wafers are heated to a desired temperature. Typically, reactant gases are passed over the heated wafer, causing the chemical vapor deposition of a thin layer of the reactant material on the wafer. Alternatively, reactant gases passing over the heated wafer will immediately react with the substrate material, as is the case in thermal oxidation.

[0003] Figure 1 shows an exemplary deposition reactor which is suited for low pressure chemical vapour deposition processes. A large number of wafers (typically at least 100) is carried by a wafer carrier, for example a slotted quartz boat, so that the gas flowing direction, which is defined by the line connecting gas inlet and gas outlet and which is parallel to the longitudinal axis of the reactor, is orthogonal to the wafer surfaces. Heating means are provided in order to heat the reactor to a predetermined temperature. As soon as the predetermined temperature is reached, the reactant gases are introduced into the deposition reactor in order to effect the deposition reaction. According to the prior art method, the temperature of the deposition reactor is maintained constant during deposition.

[0004] In order to deposit silicon dioxide, for example TEOS, ($Si(OC_2H_5)_4$) is reacted at a temperature of 700°C and a pressure of 40 Pa. Silicon nitride layers can be generated by reacting SiH_2Cl_2 and NH_3 at a temperature of 750°C and a pressure of 30 Pa.

[0005] As is generally known, the deposition rate depends on the deposition temperature and the pressure inside the deposition reactor. More specifically, a higher deposition temperature results in a higher deposition rate. Accordingly, usually a temperature gradient is applied in a direction parallel to the gas flowing direction in order to compensate for the depletion of the reactant gases in that direction. As a consequence, the temperature at the reactant gases outlet is higher than the temperature at the reactant gases inlet. By these measures, it is possible to deposit a homogenous layer thickness onto all wafers which are simultaneously processed.

[0006] However, it is not possible to achieve a sufficient in plane uniformity of the layer thickness. More specifically, the layers on the wafers close to the gas outlet tend to assume a bowl shape in which the layer thickness at the edge of the wafer is greater than the layer thickness in the middle of the wafer. Typically, the difference between layer thickness at the edge and layer thickness in the middle is approximately 10 nm at a mean value of the layer thickness of 200 nm. On the other side, the layers on the wafer close to the gas inlet tend to assume a pillow shape in which the layer thickness at the edge of the wafer is smaller than the layer thickness in the middle of the wafer.

[0007] U.S. patent US-A-5 775 889 discloses a reactor for high temperature treatment of semiconductor wafers. The wafers are held perpendicularly which respect to a reactant gas flow direction parallel to a longitudinal axis of the reactor. The heating system performs a rising and falling temperature profile during wafer processing in order to avoid crystal defects called slip. When the reaction tube has reached about 1.100 °C, oxidation gases are fed into the reaction tube.

[0008] The international patent application publication WO 00/39840 discloses a vertical oven system for boron doping of semiconductor wafers. The wafers are vertically arranged. The oven comprises several temperature zone which can be heated independently.

[0009] It is an object of the invention to provide a heating system and a method for heating a reactor for one of deposition and oxidation by which the in plane uniformity of the deposited or oxidized layer thickness is improved.

[0010] According to the present invention, the above object is achieved by a heating system according to the features of claim 1.

[0011] Moreover, the above object is achieved by a method for heating a reactor according to the features of claim 6.

[0012] As the inventors of the present invention found out, the in plane uniformity of the deposited layers can be largely improved by changing the reactor temperature during the deposition process. Accordingly, the reactor temperature is no longer held at a constant value but it is changed. For example, the temperature can be lowered, raised or changed in an arbitrary manner. Examplary temperature profiles which are applied in all the zones of the reactor are illustrated in Figures 2 and 3. As is shown in Figure 2, the temperature is ramped down by 40 K, whereas in Figure 3, during deposition which starts at point A end ends at point B, the temperature is first ramped up by 60 K and then again ramped down by 60 K. The time is depicted in abitrary units (a.u.). It is to be noted that deposition and oxidation are exchangeable in this invention. A feature of the invention which is described for a deposition reaction can equally be used for an oxidation reaction.

[0013] According to a preferred embodiment, the deposition (or oxidation) reactor is divided into a plurality (usually five) of zones along the reactant gas flowing direction. The heating system is divided into heating elements and each of the heating elements is seperately controlled so as to provide a different temperature profile indicating the temper-

ature of the specific temperature element versus time as is shown schematically in Figure 4. The number of heating elements can be the same as the number of zones. As can be seen from Figure 4, in zone 1, which is close to the gas outlet, the temperature is ramped down from 790°C to 710°C, in zone 2 the temperature is ramped down from 770°C to 730°C, in zone 3 the temperature is maintained constant at 750°C, and in zone 4, which is close to the gas inlet, the temperature is ramped up from 720°C to 780°C.

[0014] Generally stated, the temperature is ramped down in the two thirds of the reactor which are closer to the gas outlet. It is preferred that the difference between deposition starting temperature and deposition end temperature is greater in a zone closer to the gas outlet than in a zone closer to the gas inlet. Moreover, the temperature is ramped up in the third of the reactor which is closest to the gas inlet. In the zone forming the boundary between these regions, the temperature is maintained constant during deposition.

[0015] By these measures, it is possible to adjust the optimum deposition temperature in accordance with the deposition conditions which vary in dependence from the location of the specific reactor zone. In particular, the reactant gases are depleted along the reactant gas flowing direction. Moreover, in a zone closer to the gas outlet the reactant gases are as well depleted in a direction parallel to the wafer surface so that the reactant gases are most depleted in the middle of the wafers. In the zones close to the gas inlet, in particular, in the zones located in the lower third of the reactor, this effect is less important since in these zones the effect of the depletion of the reactant gases along the reactant gas flowing direction is not so strong.

[0016] Another relevant parameter is the heat flow in a direction of the wafer surface. Generally, heat is supplied by means of a heating spiral or heating lamp which is situated at the reactor walls. Accordingly, a certain temperature of the zone of the deposition reactor refers to the temperature at the wafer edge. In addition, in most commonly used deposition reactors, at a position closest to the gas inlet, redundant heating elements are provided at a position where no wafer is placed. Accordingly, in the zone closest to the gas inlet, the heating is not only effected from the wafer edge but also from the middle of the wafer. Therefore, dependent from the specific location of the zone, different heating conditions will prevail.

[0017] More specifically, in the zones which are not closest to the gas inlet, the temperature at the wafer edge is different from the temperature in the middle of the wafer. Accordingly, by lowering the temperature of the reactor, a uniform heating amount can be achieved along the wafer surface.

[0018] On the other hand, in the zone closest to the gas inlet, the heating is not only effected from the edge as explained above. As a consequence, by raising the temperature of the reactor during the deposition, a uniform heating amount can be achieved along the wafer surface.

[0019] The effects of the present invention can be further improved if the temperature profiles of the zones are properly set so that the temperature profiles of neighbouring zones do not cross each other during the deposition process. Stated more concretely, the elevation of the temperature of one zone should be avoided, if at the same time the temperature of a neighbouring zone is lowered in order to minimize a detrimental heat flow between the zones.

[0020] The detrimental heat flow can be best suppressed if the deposition process ends at the same temperature in all zones.

[0021] Since different deposition reactors require different heating conditions, a calibration can be performed, as soon as a new batch of wafers has been processed. To this end, after the end of the deposition, the wafers of each zone are evaluated, for example using an ellipsometer. Thereafter, on the basis of the measurement results obtained, the heating conditions for the zones of the reactor are set for the next deposition processes. If the deposited layer has assumed a bowl shape, the difference between deposition start temperature and deposition end temperature must be increased in that specific zone. On the contrary, if the deposited layer assumes a pillow shape, the difference between deposition start temperature and deposition end temperature must be decreased in that specific zone.

[0022] In order to deposit the same layer thickness onto the wafers in all the zones, it is preferred that the mean value of the temperature taken over time in each of the zones is decreasing from the zone closest to the gas outlet to the zone closest to the gas inlet. For example, zone 1 assumes a mean temperature of 800°C, zone 2 assumes a mean temperature of 790°C, zone 3 assumes a mean temperature of 780°C, zone 4 assumes a mean temperature of 770°C, and zone 5 assumes a mean temperature of 760°C. This is preferred when the temperature is equally changed in all the zones, for example, lowered by a certain amount, raised by a certain amount or changed in an arbitrary manner, or when the temperature profile of every zone is changed in a different manner.

[0023] In summary, the present invention provides the following advantages:

- The in plane uniformity of the deposited layers is largely improved. In particular, a difference between the layer thickness at the edge and the layer thickness in the middle of the wafer amounts to 4 nm at most if the mean value of the layer thickness amounts to 200 nm.

- The present invention can easily be implemented to existing deposition reactors.

- As is generally known, by raising the pressure inside the deposition reactor, the deposition rate can be raised. However, a high pressure will also result in very inhomogenous layers. By additionally regulating the temperature in accordance with the present invention, the homogenity of the layers will be improved. Accordingly, when the present invention is applied to a deposition process which is performed at an elevated pressure, the deposition rate is raised and, simultaneously, the quality of the layers in terms of their homogenity is maintained.

- The present invention can be applied to all low pressure chemical vapour deposition processes. It is particularly applicable to the deposition of silicon nitride, silicon dioxide (TEOS process and thermal oxidation), arsene oxide (TEAS process) and polysilicon layers. The advantageous effects of the present invention become especially apparent at a layer thickness of at least 30 nm. If the layer thickness is smaller, the advantages become less apparent.

[0024] The present invention will be explained in more detail with reference to the accompanying drawings in conjunction with deposition, although the invention also includes oxidation processes.

Figure 1	illustrates a CVD reactor which can be used for implementing the present invention;
Figures 2, 3 and 4	show examplary temperature profiles applied to the deposition reactor; and
Figure 5	shows the measurement results representing the uniformity of layers deposited in accordance with the examples and the comparative example.

[0025] In Figure 1, reference numeral 1 denotes a deposition reactor in which the low pressure chemical vapour deposition takes place and which is implemented as a batch furnace. Reference numeral 2 denotes gas inlet for feeding one or more reactant gases to the deposition reactor, and reference numeral 3 denotes a gas outlet for exhausting the reactant gases. As is obvious, the reactant gas flowing direction is parallel to the longitudinal axis of the reactor. Reference numeral 4 denotes a wafer carrier for carrying a plurality (usually between 100 and 150) of wafers, and reference numeral 5 denotes a heating system for heating the deposition reactor.
[0026] The reactor may be divided into 5 zones, zone 1 to zone 5, wherein zone 1 is the zone closest to the gas outlet, whereas zone 5 is the zone closest to the gas inlet. In Figure 1, reference numeral 6 denotes zone 1 and reference numeral 7 denotes zone 5.
[0027] In the present examples, a pad nitride layer is to be deposited onto silicon wafers. After that, trenches for defining storage capacitors for DRAM cells are to be etched into these wafers.
[0028] After introducing the wafers into the deposition reactor, the reactor is evacuated, and the temperature thereof is raised. Usually, the reactor is held at a standby temperature of approximately 650°C so that the temperature is to be increased by about 100 to 250°C depending on the chosen reaction conditions. As soon as a desired vacuum degree is reached, a first reactant gas is fed into the reactor. In the present case, NH_3 at a flow rate of 480 sccm (standard cubic centimeters per second) is fed into the reactor. As soon as the desired deposition temperature is reached, a second reactant gas, which is SiH_2Cl_2 at a flow rate of 120 sccm, is fed into the reactor so that the deposition reaction will start. A typical pressure inside the deposition reactor amounts to 14,63 Pa (110 mTorr).
[0029] The temperatures at which the deposition starts and the temperature profiles during deposition are varied in accordance with the following examples and the comparative example. Since the temperature profiles are selected so that the mean temperature amounts to 800°C in zone 1, 790°C in zone 2, 780°C in zone 3, 770°C in zone 4, and 760°C in zone 5, the deposition rate amounts to 2 nm/min.
[0030] The layers are deposited at a mean value of the thickness of 200 nm within a time period of 100 minutes.

Example 1

[0031] The reactor is brought to a temperature of 820°C in zone 1, 810°C in zone 2, 800°C in zone 3, 790°C in zone 4, and 780°C in zone 5. During deposition, the reactor temperature is ramped down by 40 K in all the zones.

Example 2

[0032] The reactor is brought to a temperature of 840°C in zone 1, 830°C in zone 2, 820°C in zone 3, 810°C in zone 4, and 800°C in zone 5. During deposition, the reactor temperature is ramped down by 80 K in all the zones.

Example 3

[0033] The reactor is brought to a temperature of 840°C in zone 1, 830°C in zone 2, 820°C in zone 3, a temperature

of 790°C in zone 4 and a temperature of 760°C in zone 5. During deposition, the temperature is ramped down by 80 K in zones 1 to 3, the temperature is ramped down by 40 K in zone 4, and it is held constant in zone 5.

Example 4

[0034] The reactor is brought to a temperature of 840°C in zone 1, 830°C in zone 2, 810°C in zone 3, 790°C in zone 4 and 750°C in zone 5. During deposition, the temperature is ramped down by 80 K in zones 1 and 2, the temperature is ramped down by 60 K in zone 3, the temperature is ramped down by 40 K in zone 4, and the temperature is ramped up by 20 K in zone 5.

Example 5

[0035] The reactor is brought to a temperature of 840°C in zone 1, 830°C in zone 2, 820°C in zone 3, 785°C in zone 4 and 740°C in zone 5. During deposition, the temperature is ramped down by 80 K in zones 1 to 3, the temperature is ramped down by 30 K in zone 4, and the temperature is ramped up by 40 K in zone 5.

Example 6

[0036] The reactor is brought to a temperature of 841°C in zone 1, 832°C in zone 2, 820°C in zone 3, 790°C in zone 4 and 734°C in zone 5. During deposition, the temperature is ramped down by 82 K in zone 1, the temperature is ramped down by 84 K in zone 2, the temperature is ramped down by 80 K in zone 3, the temperature is ramped down by 40 K in zone 4, and the temperature is ramped up by 52 K in zone 5.

Comparative example

[0037] The reactor is brought to a temperature of 800°C in zone 1, 790°C in zone 2, 780°C in zone 3, 770°C in zone 4, and 760°C in zone 5. During deposition, the temperature is held constant in all zones.

[0038] When the deposition reaction is finished, the flow of the reactant gases is interrupted and the reactor is rinsed with an inert gas such as nitrogen.

[0039] Thereafter the quality of the deposited layers is evaluated as follows. The standard deviation from the mean value of the layer thickness based on 13 measurement points on the wafer surface is determined for each of the examples and the comparative example, and the results represented by uniformity sigma % are given in the following table:

Example	zone 1 [%]	zone 2 [%]	zone 3 [%]	zone 4 [%]	zone 5 [%]
1	1,14	0,92	0,77	0,37	1,07
2	0,45	0,61	0,54	0,41	1,78
3	0,49	0,59	0,22	0,17	0,95
4	0,64	0,74	0,67	0,31	0,85
5	0,58	0,73	0,47	0,32	0,69
6	0,71	0,73	0,57	0,29	0,66
comparative	1,78	1,38	1,19	1,03	0,69

[0040] The measurement results for examples 1, 2, 5 and the comparative example are illustrated in Figure 5.

[0041] As can be seen from the table, all of the examples provide a layer thickness having an improved in plane uniformity in zones 1 to 4, whereas only examples 5 and 6 provide an improved uniformity in zone 5.

[0042] However, since in normally used deposition reactors the positions of the wafer carrier of zone 5 closest to the gas inlet and the positions of the wafer carrier of zone 1 closest to the gas outlet are occupied by dummy wafers which are not used for chip production, the deteriorated in plane uniformity in zone 5 is of minor relevance for the chip production.

[0043] In summary, the present invention provides improved results in examples 1 to 4 and excellent results in examples 5 and 6.

Claims

1. A heating system (5) for heating a reactor (1) for one of deposition and oxidation of a plurality of semiconductor wafers in which the plurality of wafers is held perpendicularly to a reactant gas flow direction which is parallel to a longitudinal axis of the reactor (1) so as to enable a deposition process or an oxidation process, the heating system (5) being adapted to change the temperature within the reactor during the deposition or oxidation process,
characterized in that
said heating system (5) comprises a plurality of heating elements each corresponding to a respective one of a plurality of reactor zones, that the heating element of each zone is adapted to perform a temperature behaviour according to a temperature profile versus time, that a heating element corresponding to a zone (7) close to a gas inlet (2) for feeding one or more reactant gases to the reactor (1) is adapted to perform a temperature behaviour according to a temperature profile which rises during the process, and that a heating element corresponding to a zone close to a gas outlet (3) for exhausting the reactant gases from the reactor (1) is adapted to perform a temperature behaviour according to a temperature profile which falls during the process.

2. The heating system (5) according to claim 1,
characterized in that
at least two heating elements corresponding to zones close to the gas outlet (3) are adapted to perform temperature behaviour according to respective temperature profiles for which the differences between a respective process start temperature and a respective process end temperature is greater for a zone closer to the gas outlet than for a zone closer to the gas inlet.

3. The heating system (5) according to claim 1 or 2,
characterized in that
the heating elements are adapted to perform temperature behaviour according to temperature profiles such that the temperature profiles of neighbouring zones do not cross each other during the process.

4. The heating system (5) according to claim 3,
characterized in that
the heating elements are adapted to provide an identical end temperature of the process (5) in each of the plurality of heating zones.

5. The heating system (5) according to any of claims 2 to 4,
characterized in that
the heating system comprises at least four heating elements each corresponding to a respective reactor zone, that a first heating element is disposed close to a gas inlet (2) for feeding one or more reactant gases to the reactor (1), a second heating element is disposed between the first heating element and a gas outlet (3) for exhausting the reactant gases from the reactor (1), a third heating element is disposed between the first heating element and the gas outlet (3), and a fourth heating element is disposed between the third heating element the gas outlet (3), that the first heating element performs a temperature behaviour according to a temperature profile which rises during the deposition or oxidation process, that the second heating element performs a temperature behaviour according to a temperature profile which is maintained constant during the deposition or oxidation process, and that the third and fourth heating elements each perform a temperature behaviour according to a temperature profile which falls during the deposition or oxidation process.

6. A method for heating a reactor (1) for one of deposition and oxidation of a plurality of semiconductor wafers in which the plurality of wafers is held perpendicularly to a reactant gas flow direction which is parallel to a longitudinal axis of the reactor (1) so as to enable a deposition process or an oxidation process, said reactor comprising a plurality of reactor zones wherein the reactor zones are each heated according to different temperature profiles versus time during the deposition or oxidation process,
characterized in that
the temperature of the zone (7) closest to a gas inlet (2) for feeding one or more reactant gases to the reactor (1) is increased during the process and that the temperature of a zone close to the gas outlet (3) for exhausting the reactant gases from the reactor (1) is decreased during the process.

7. A method for heating a reactor (1) according to claim 6,
characterized in that
the temperature of at least two zones close to gas outlet (3) is decreased such that the difference between the

process start temperature and the process end temperature is greater in a zone closer to the gas outlet than in a zone closer to the gas inlet.

8. The method for heating a reactor (1) according to claim 6 or 7,
characterized in that
the temperature profiles are such that the temperature profiles of neighbouring zones do not cross each other during the process.

9. The method for heating a reactor (1) according to claim 8,
characterized in that
the temperature profiles are such that the end temperature of the process is the same in each zone.

10. The method according to anyone of claims 6 to 9,
characterized in that
the heating system comprises at least four heating elements each corresponding to a respective reactor zone, that a first heating element is disposed close to a gas inlet (2) for feeding one or more reactant gases to the reactor (1), a second heating element is disposed between the first heating element and a gas outlet (3) for exhausting the reactant gases from the reactor (1), a third heating element is disposed between the first heating element and the gas outlet (3), and a fourth heating element is disposed between the third heating element the gas outlet (3), that the first heating element performs a temperature behaviour according to a temperature profile which rises during the deposition or oxidation process, that the second heating element performs a temperature behaviour according to a temperature profile which is maintained constant during the deposition or oxidation process, and that the third and fourth heating elements each perform a temperature behaviour according to a temperature profile which falls during the deposition or oxidation process.

Patentansprüche

1. Heizssystem (5) zum Heizen eines Reaktors (1) für die Abscheidung oder Oxidation einer Vielzahl von Halbleiterwafern, in dem die Vielzahl von Halbleiterwafern senkrecht zu einer Reaktionsgasströmungsrichtung gehaltert sind, die parallel zu einer Längsachse des Reaktors (1) liegt, um einen Abscheidungsprozess oder einen Oxidationsprozess zu ermöglichen, wobei das Heizssystem (5) dafür ausgelegt ist, die Temperatur innerhalb des Reaktors während des Abscheidungs- oder Oxidationsprozesses zu ändern,
dadurch gekennzeichnet, dass
das Heizssystem (5) eine Vielzahl von Heizelementen umfasst, die jeweils einer entsprechenden Reaktorzone einer Vielzahl von Reaktorzonen entsprechen, dass das Heizelemente jeder Zone dafür ausgelegt ist, ein Temperaturverhalten gemäß einem Temperaturprofil über die Zeit aufzuweisen, dass ein Heizelement, das einer Zone (7) nahe dem Gaseinlass (2) zur Zufuhr von einem oder mehreren Reaktionsgasen in den Reaktor (1) zugeordnet ist, dafür ausgelegt ist, ein Temperaturverhalten gemäß einem Temperaturprofil aufzuweisen, das während des Prozesses anwächst, und dass ein Heizelement, das einer Zone nahe dem Gasauslass (3) zur Abfuhr der Reaktionsgase aus dem Reaktor (1) zugeordnet ist, dafür ausgelegt ist, ein Temperaturverhalten gemäß einem Temperaturprofil aufzuweisen, das während des Prozesses abfällt.

2. Heizssystem (5) nach Anspruch 1,
dadurch gekennzeichnet, dass
zumindest zwei Heizelemente, die Zonen nahe dem Gasauslass (3) zugeordnet sind, dafür ausgelegt sind, ein Temperaturverhalten gemäß jeweiligen Temperaturprofilen aufzuweisen, für die die Differenz zwischen einer jeweiligen Prozessstarttemperatur und einer jeweiligen Prozessendtemperatur größer ist für eine Zone näher am Gasauslass als für eine Zone näher am Gaseinlass.

3. Heizssystem (5) nach Anspruch 1 oder 2,
dadurch gekennzeichnet, dass
die Heizelemente dafür ausgelegt sind, ein Temperaturverhalten gemäß Temperaturprofilen aufzuweisen, so dass die Temperaturprofile von benachbarten Zonen sich während des Prozesses nicht überkreuzen.

4. Heizssystem (5) nach Anspruch 3,
dadurch gekennzeichnet, dass
die Heizelemente dafür ausgelegt sind, dass sie eine identische Endtemperatur des Prozesses (5) in jeder der

Vielzahl von Heizzonen liefern.

5. Heizssystem (5) nach einem der Ansprüche 2 bis 4,
dadurch gekennzeichnet, dass
das Heizssystem zumindest vier Heizelemente umfasst, die jeweils einer entsprechenden Reaktorzone entsprechen, dass ein erstes Heizelement nahe einem Gaseinlass (2) zur Zufuhr von einem oder mehreren Reaktionsgasen in den Reaktor (1) angeordnet ist, dass ein zweites Heizelemente zwischen dem ersten Heizelement und dem Gasauslass (3) zur Abfuhr der Reaktionsgase aus dem Reaktor (1) angeordnet ist, dass ein drittes Heizelement zwischen dem ersten Heizelement und dem Gasauslass (3) angeordnet ist und ein viertes Heizelement zwischen dem dritten Heizelement und dem Gasauslass (3) angeordnet ist, dass das erste Heizelement ein Temperaturverhalten gemäß einem Temperaturprofil aufweist, das während des Abscheidungs- oder Oxidationsprozesses ansteigt, dass das zweite Heizelement ein Temperaturverhalten gemäß einem Temperaturprofil aufweist, das während des Abscheidungs- oder Oxidationsprozesses konstant gehalten wird, und dass das dritte Heizelement und vierte Heizelement jeweils ein Temperaturverhalten gemäß einem Temperaturprofil aufweist, das während des Abscheidungs- oder Oxidationsprozesses abfällt.

6. Verfahren zum Heizen eines Reaktors (1) für die Abscheidung oder Oxidation einer Vielzahl von Halbleiterwafern, in dem die Vielzahl von Halbleiterwafern senkrecht zu einer Reaktionsgasströmungsrichtung gehaltert sind, die parallel zu einer Längsachse des Reaktors (1) ist, um einen Abscheidungsprozess oder einen Oxidationsprozess zu ermöglichen, wobei der Reaktor eine Vielzahl von Reaktionszonen aufweist, die jeweils gemäß unterschiedlichen Temperaturprofilen über der Zeit während des während des Abscheidungs- oder Oxidationsprozesses geheizt werden,
dadurch gekennzeichnet, dass
die Temperatur der Zone (7), die einem Gaseinlass (2) zur Zufuhr von einem oder mehreren Reaktionsgasen in den Reaktor (1) am nächsten ist, während des Prozesses erhöht wird und dass die Temperatur einer Zone nahe dem Gasauslass (3) zur Abfuhr der Reaktionsgase aus dem Reaktor (1) während des Prozesses vermindert wird.

7. Verfahren zum Heizen eines Reaktors (1) nach Anspruch 6,
dadurch gekennzeichnet, dass
die Temperatur von zumindest zwei Zonene nahe dem Gasauslass (3) vermindert wird, so dass die Differenz zwischen der Prozessstarttemperatur und der Prozessendtemperatur größer ist in einer Zone näher am Gasauslass als in einer Zone näher am Gaseinlass.

8. Verfahren zum Heizen eines Reaktors (1) nach Anspruch 6,
dadurch gekennzeichnet, dass
die Temperaturprofile derart sind, dass die Temperaturprofile von benachbarten Zonen sich während des Prozesses nicht überkreuzen.

9. Verfahren zum Heizen eines Reaktors (1) nach Anspruch 8,
dadurch gekennzeichnet, dass
die Temperaturprofile derart sind, dass die Endtemperatur des Prozesses in jeder Zone gleich ist.

10. Verfahren nach einem der Ansprüche 6 bis 9,
dadurch gekennzeichnet, dass
das Heizssystem zumindest vier Heizelemente umfasst, die jeweils einer entsprechenden Reaktorzone entsprechen, dass ein erstes Heizelement nahe einem Gaseinlass (2) zur Zufuhr von einem oder mehreren Reaktionsgasen in den Reaktor (1) angeordnet ist, dass ein zweites Heizelemente zwischen dem ersten Heizelement und dem Gasauslass (3) zur Abfuhr der Reaktionsgase aus dem Reaktor (1) angeordnet ist, dass ein drittes Heizelement zwischen dem ersten Heizelement und dem Gasauslass (3) angeordnet ist und ein viertes Heizelement zwischen dem dritten Heizelement und dem Gasauslass (3) angeordnet ist, dass das erste Heizelement ein Temperaturverhalten gemäß einem Temperaturprofil aufweist, das während des Abscheidungs- oder Oxidationsprozesses ansteigt, dass das zweite Heizelement ein Temperaturverhalten gemäß einem Temperaturprofil aufweist, das während des Abscheidungs- oder Oxidationsprozesses konstant gehalten wird, und dass das dritte Heizelement und vierte Heizelement jeweils ein Temperaturverhalten gemäß einem Temperaturprofil aufweisen, das während des Abscheidungs- oder Oxidationsprozesses abfällt.

Revendications

1. Dispositif (5) de chauffage pour chauffer un réacteur (1) pour un dépôt ou une oxydation d'une pluralité de plaquettes de semi-conducteur, dans lequel la pluralité de plaquettes est maintenue de façon perpendiculaire à une direction d'écoulement de gaz réactifs qui est parallèle à un axe longitudinal du réacteur (1), de manière à permettre un traitement de dépôt ou un traitement d'oxydation, le dispositif (5) de chauffage étant conçu pour modifier la température à l'intérieur du réacteur, pendant le traitement de dépôt ou d'oxydation,
   caractérisé en ce que :

   le dispositif (5) de chauffage comprend une pluralité d'éléments chauffants, correspondant chacun à une zone respective parmi une pluralité de zones du réacteur,
   l'élément chauffant de chaque zone est conçu pour adopter un comportement thermique suivant un profil de température par rapport au temps,
   un élément chauffant, correspondant à une zone (7) voisine d'une admission (2) de gaz pour alimenter le réacteur (1) en un ou plusieurs gaz réactif(s), est conçu pour adopter un comportement thermique suivant un profil de température qui s'élève pendant le traitement, et
   un élément chauffant, correspondant à une zone voisine d'une sortie (3) de gaz pour l'échappement des gaz réactifs du réacteur (1), est conçu pour adopter un comportement thermique suivant un profil de température qui s'abaisse pendant le traitement.

2. Dispositif (5) de chauffage suivant la revendication 1, **caractérisé en ce qu'**au moins deux éléments chauffants correspondant à des zones voisines de la sortie (3) de gaz sont conçus pour adopter un comportement thermique suivant des profils de température respectifs, pour lesquels l'écart entre une température de début de traitement respective et une température de fin de traitement respective est plus grand pour une zone plus proche de la sortie de gaz que pour une zone plus proche de l'admission de gaz.

3. Dispositif (5) de chauffage suivant la revendication 1 ou 2, **caractérisé en ce que** les éléments chauffants sont conçus pour adopter un comportement thermique suivant des profils de température, de sorte que les profils de température de zones voisines ne se croisent pas les uns avec les autres au cours du traitement.

4. Dispositif (5) de chauffage suivant la revendication 3, **caractérisé en ce que** les éléments chauffants sont conçus pour produire une température finale identique du traitement (5) dans chacune des zones parmi la pluralité de zones de chauffage.

5. Dispositif (5) de chauffage suivant l'une quelconque des revendications 2 à 4, **caractérisé en ce que** :

   le dispositif de chauffage comprend au moins quatre éléments chauffants correspondant chacun à une zone respective du réacteur,
   un premier élément chauffant est disposé à proximité d'une admission (2) de gaz pour alimenter le réacteur (1) en un ou plusieurs gaz réactif(s),
   un deuxième élément chauffant est disposé entre le premier élément chauffant et une sortie (3) de gaz, pour l'échappement des gaz réactifs du réacteur (1),
   un troisième élément chauffant est disposé entre le premier élément chauffant et la sortie (3) de gaz, et
   un quatrième élément chauffant est disposé entre le troisième élément chauffant et la sortie (3) de gaz,
   le premier élément chauffant adopte un comportement thermique suivant un profil de température qui s'élève pendant le traitement de dépôt ou d'oxydation,
   le deuxième élément chauffant adopte un comportement thermique suivant un profil de température qui est maintenu constant pendant le traitement de dépôt ou d'oxydation, et
   les troisième et quatrième éléments chauffants adoptent chacun un comportement thermique suivant un profil de température qui s'abaisse pendant le traitement de dépôt ou d'oxydation.

6. Procédé pour chauffer un réacteur (1) pour un dépôt ou une oxydation d'une pluralité de plaquettes de semi-conducteur, dans lequel la pluralité de plaquettes est maintenue de façon perpendiculaire à une direction d'écoulement de gaz réactifs qui est parallèle à un axe longitudinal du réacteur (1), de manière à permettre un traitement de dépôt ou un traitement d'oxydation, le réacteur comprenant une pluralité de zones de réacteur dans lesquelles les zones de réacteur sont chauffées chacune suivant différents profils de température par rapport au temps, pendant le traitement de dépôt ou d'oxydation,
   caractérisé en ce que :

la température de la zone (7) la plus proche d'une admission (2) de gaz pour alimenter le réacteur (1) en un ou plusieurs gaz réactif(s), augmente pendant le traitement, et
la température d'une zone voisine de la sortie (3) de gaz pour l'échappement des gaz réactifs à partir du réacteur (1), diminue pendant le traitement.

7. Procédé pour chauffer un réacteur (1) suivant la revendication 6, **caractérisé en ce que** la température d'au moins deux zones voisines de la sortie (3) de gaz diminue de telle sorte que l'écart entre la température de démarrage de traitement et la température de fin de traitement est supérieur dans une zone plus proche de la sortie de gaz que dans une zone plus proche de l'admission de gaz.

8. Procédé pour chauffer un réacteur (1) suivant la revendication 6 ou 7, **caractérisé en ce que** les profils de température sont tels que les profils de température de zones voisines ne se croisent pas les uns avec les autres pendant le traitement.

9. Procédé pour chauffer un réacteur (1) suivant la revendication 8, **caractérisé en ce que** les profils de température sont tels que la température de fin de traitement est la même dans chaque zone.

10. Procédé suivant l'une quelconque des revendications 6 à 9, **caractérisé en ce que** :

le dispositif de chauffage comprend au moins quatre éléments chauffants correspondant chacun à une zone respective de réacteur,
un premier élément chauffant est disposé à proximité d'une admission (2) de gaz pour alimenter le réacteur (1) en un ou plusieurs gaz réactif(s),
un deuxième élément chauffant est disposé entre le premier élément chauffant et une sortie (3) de gaz pour l'échappement des gaz réactifs du réacteur (1),
un troisième élément chauffant est disposé entre le premier élément chauffant et la sortie (3) de gaz, et
un quatrième élément chauffant est disposé entre le troisième élément chauffant et la sortie (3) de gaz,
le premier élément chauffant adopte un comportement thermique suivant un profil de température qui s'élève pendant le traitement de dépôt ou d'oxydation,
le deuxième élément chauffant adopte un comportement thermique suivant un profil de température qui est maintenu constant pendant le traitement de dépôt ou d'oxydation, et
les troisième et quatrième éléments chauffants adoptent chacun un comportement thermique suivant un profil de température qui s'abaisse pendant le traitement de dépôt ou d'oxydation.

FIG 1

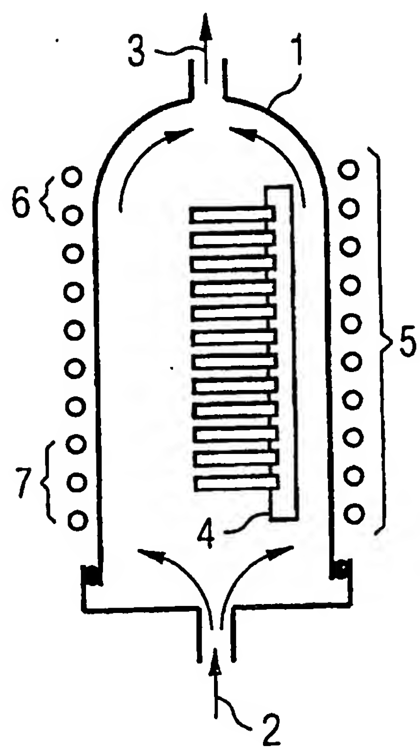

FIG 2

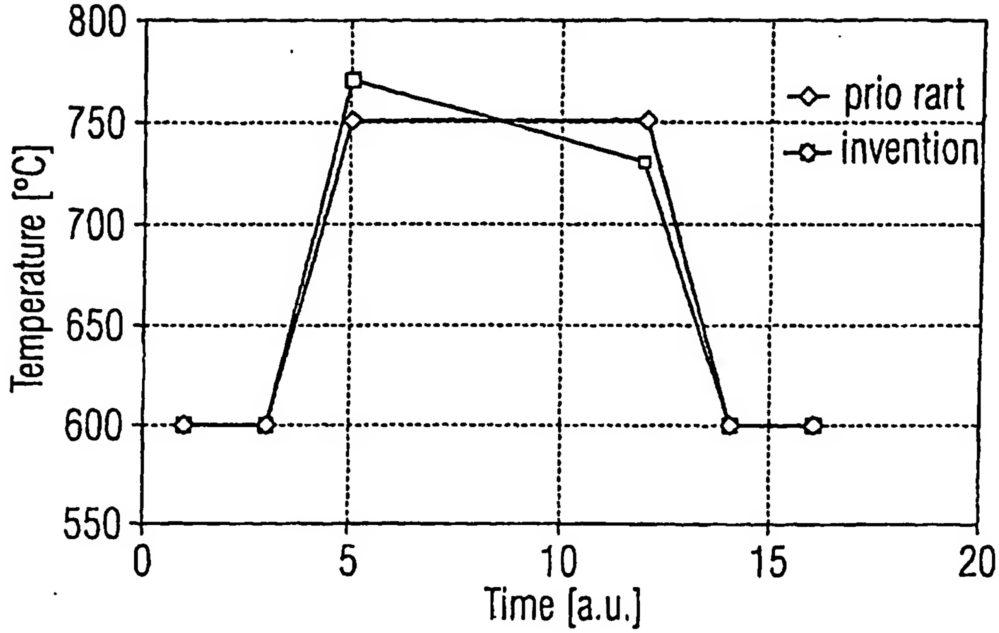
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FIG 3

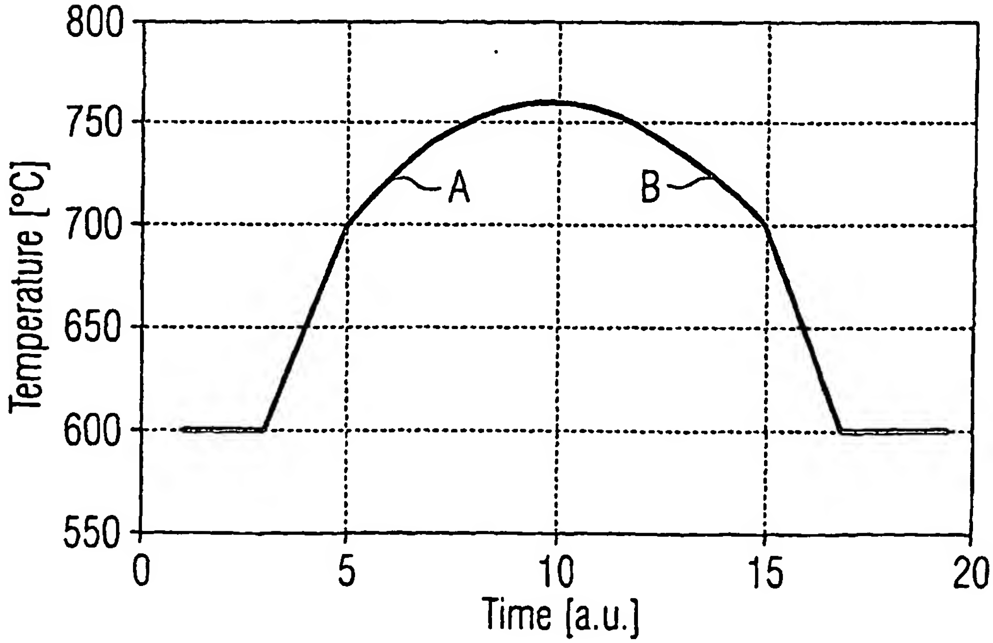
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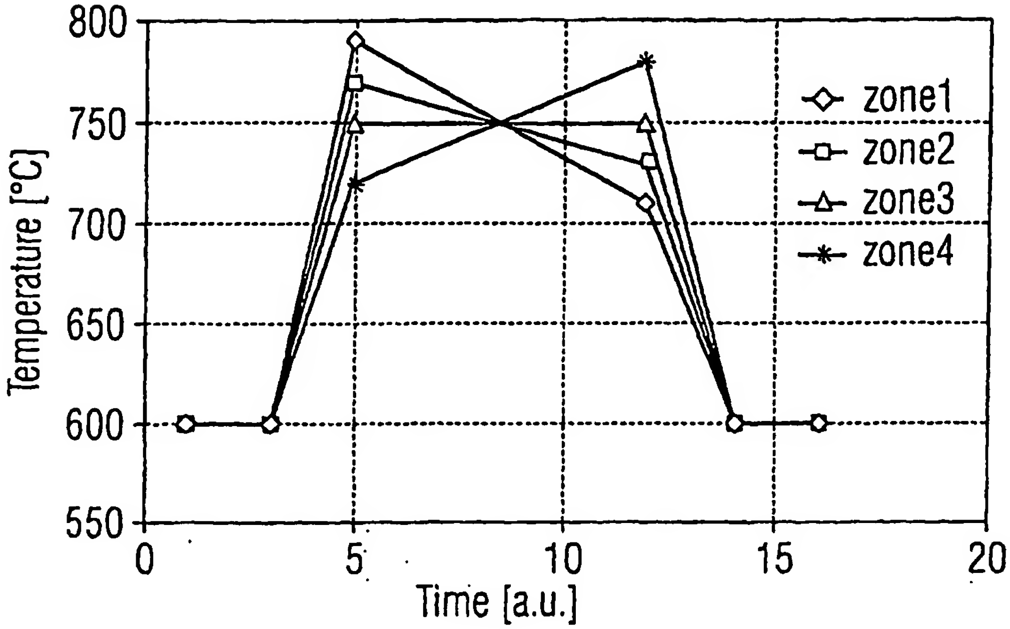
FIG 4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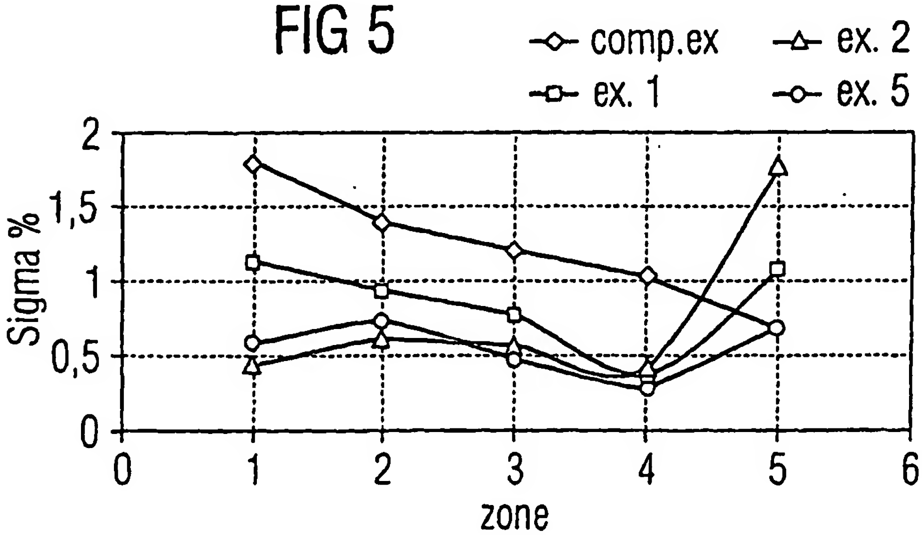
zone1
zone2
zone3
zone4

FIG 5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